PATENT SPECIFICATION

DRAWINGS ATTACHED

1,006,342

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Date of Application and filing Complete Specification Dec. 18, 1962.
No. 47805/62.
Application made in France (No. 882771) on Dec. 21, 1961.
Application made in France (No. 914714) on Nov. 7, 1962.
Complete Specification Published Sept. 29, 1965.

Index at acceptance:—F4 H(G3E, G3H, G3N, G3S, G3X3, G8); F1 G1A
Int. Cl.:—F 25 b//F 02 c

COMPLETE SPECIFICATION

Improvements in Cooling Installations for High-Speed Aircraft

ERRATUM

SPECIFICATION No. 1,006,342
Amendment No. 1

Page 1, line 2, Applicants' name, *for* "SOCIETE D'EXPLOITATION DES MATERIALS HISPANOSUIZA" *read* "SOCIETE D'EXPLOITATION DES MATERIELS HISPANO-SUIZA"

THE PATENT OFFICE
6th June 1966

the compressor is advantageously surrounded by the heat exchanger, which is given an annular form.

The invention is more especially concerned, but not exclusively, with cooling installations which are intended to be accommodated in a restricted space, for example in a nacelle externally of the normal structure of the aircraft in question (such as a nacelle externally of the fuselage and wing system in the case of an aeroplane).

The object of the invention is more especially to make these installations such that they meet the various requirements of practical work better than has been the case hitherto, more particularly from the point of view of their effectiveness and compactness.

According to the present invention there is provided cooling installation for high-speed aircraft, of the type wherein air collected by an air intake which is forwardly

tion of the speed of this second turbine.

The outlet through which the air is discharged rearwardly may be provided with means such that they make it possible to vary the cross-section of the outlet offered to the air discharged by the compressor in dependence on variations of any desired factor.

The invention is illustrated by way of example in the accompanying drawings, in which:

Figures 1, 2, 3 and 4 show, each in diagrammatic axial half-section, four cooling installations arranged according to four embodiments of the invention;

Figure 5 is a developed sectional view on the line V—V of Figure 4; and

Figure 6 shows a further embodiment of cooling installation according to the invention.

Referring to the drawings, to construct a cooling installation of the kind in question,

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COMPLETE SPECIFICATION

Improvements in Cooling Installations for High-Speed Aircraft

We, SOCIETE D'EXPLOITATION DES MATERIALS HISPANOSUIZA, a French Body Corporate of rue du Capitaine Guynemer, Bois Colombes (Seine) France, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to cooling installations for high-speed aircraft, of the type wherein air taken in through a forwardly directed air intake is expanded in a driving turbine which drives a compressor, the cooled air issuing from the turbine passing through a heat exchanger wherein heat is dissipated from the fluid to be cooled, and then the said air passes through the said compressor from which it is ejected preferably rearwardly and outwardly. In such installations, a shaft connecting the turbine to the compressor is advantageously surrounded by the heat exchanger, which is given an annular form.

The invention is more especially concerned, but not exclusively, with cooling installations which are intended to be accommodated in a restricted space, for example in a nacelle externally of the normal structure of the aircraft in question (such as a nacelle externally of the fuselage and wing system in the case of an aeroplane).

The object of the invention is more especially to make these installations such that they meet the various requirements of practical work better than has been the case hitherto, more particularly from the point of view of their effectiveness and compactness.

According to the present invention there is provided cooling installation for high-speed aircraft, of the type wherein air collected by an air intake which is forwardly directed is expanded in a driving turbine which drives a compressor, the cooled air issuing from the turbine passing through a heat exchanger where the heat of a cooling fluid returning from apparatus to be cooled is dissipated, and then the said air passes through the said compressor from which it is ejected preferably outwardly and rearwardly, characterised in that the said installation is completed by means for generating electrical energy, preferably in the form of a constant-frequency alternating current, the motive power for said energy generating means being provided by the air flowing through the installation.

This arrangement may advantageously be achieved by adding to the installation, in series with the turbine which drives the compressor, a second independent turbine which drives an electric generator, means being provided for automatically effecting the regulation of the speed of this second turbine.

The outlet through which the air is discharged rearwardly may be provided with means such that they make it possible to vary the cross-section of the outlet offered to the air discharged by the compressor in dependence on variations of any desired factor.

The invention is illustrated by way of example in the accompanying drawings, in which:

Figures 1, 2, 3 and 4 show, each in diagrammatic axial half-section, four cooling installations arranged according to four embodiments of the invention;

Figure 5 is a developed sectional view on the line V—V of Figure 4; and

Figure 6 shows a further embodiment of cooling installation according to the invention.

Referring to the drawings, to construct a cooling installation of the kind in question,

for example in order to use it for equipping a nacelle or container 1 at the end of the wing of a supersonic aircraft, this nacelle containing equipment or a material which has to be protected from the heat developed by the friction of the air at high speeds along the wall of the said nacelle and/or by the functioning of an apparatus contained in the nacelle, the following or similar procedure is adopted.

In all cases, an air intake 2 making it possible to take in the desired rate of flow of air for the different conditions of use is arranged preferably right at the end of the nose of the nacelle, the configuration of this intake being adapted to the conditions of flight imposed on the aeroplane.

This air intake is made annular and is arranged about an axial cone 3.

Behind this air intake, there is provided a diffuser 4 which slows down the air which has been taken in, this diffuser terminating in front of the distributor 5 of an axial or centripetal turbine 6 comprising at least one stage.

At the outlet side of this turbine there is arranged an annular heat exchanger 7 which is mounted in the space provided rearwardly of the turbine between the outer wall or cowling of the nacelle and the shaft 8 (or the shaft support) of the said turbine, the said shaft being prolonged rearwardly to the compressor 9, which is an axial or centrifugal compressor comprising at least one stage, withdrawing air from the outlet of the exchanger 7 and delivering it for ejection preferably rearwardly and outwardly.

Thus, in the drawings, an outlet 10 has been provided which is substantially tangential to the outer wall of the nacelle, and in which are arranged the vanes 11 of a rectifier which makes it possible, where necessary, to discharge the air out of the nozzle without residual rotation.

Of course, the heat exchanger 7 will be adapted to the nature of the fluid which it is to cool (gas or liquid). The heat exchanger can be of any appropriate constructional form.

This being so, the turbo-cooler group as just described is supplemented in such a manner that the installation is capable of supplying a certain amount of electrical energy. According to the forms of embodiment illustrated in Figures 1 to 4, it will be assumed that the electrical energy is to be supplied in the form of a constant-frequency alternating current.

According to the embodiments of the invention shown in Figures 1 and 2, it is the work performed by the turbine 6, which already drives the compressor 9, which is in part used for driving an alternator 12 also.

But special arrangements must then be adopted if it is desired that the alternating current produced has a substantially constant frequency.

Thus, it is possible, as shown in Figure 1, to use a rotating machine i.e. compressor or turbine, with fixed geometry, i.e. with blades (fixed or turning) which have a fixed setting, the alternator 12 being situated rearwardly of the shaft 8 of the turbine 6 and of the compressor 9, and a reduction gear 13 being interposed between the shaft 8 and the shaft of the alternator in order to drive the said alternator.

The rotational speed of the rotating assembly, and therefore also the frequency of the alternating current at the output terminals of the alternator, is normally variable in accordance with the flying conditions of the aircraft, and thus in order to bring this frequency into a constant value, there is provided at the output of the alternator a frequency compensating device 14.

In the case of a fixed-geometry rotating machine (and the same would apply if it were a question of an installation purely used for cooling without the generating of electricity) the geometry of the rotating machine is calculated so as to permit the production of a predetermined minimum calorific power under the most difficult flying conditions that is to say:

—Maximum Mach number for the flow speed considered,

—lowest ambient pressure (high altitude).

If the machine does not have any regulatable cross-section, its cooling capacity varies with flying conditions (e.g. Mach number and altitude). At any given altitude, this cooling capacity increases when the Mach number decreases, passes through a maximum value and then decreases.

The regulation of the cooling capacity of the installation can be ensured by a device such as that shown in Figure 1 wherein there is connected to a duct 15 leading from the exchanger 7 to the apparatus to be cooled, a thermostat 16 which acts when necessary on an electro-magnetic valve 17 so as to pass directly to the duct 15, by a by-pass 18, at least part of the delivery of a pump 19 which also supplies to the exchanger 7 through a duct 20 the remainder of the fluid which has passed through the apparatus 21 to be cooled. In this way the temperature of the fluid arriving at the said apparatus 21 can be regulated.

It is also possible, as shown in Figure 2, to keep the rotational speed of the shaft 8 substantially constant by acting on the geometry of the rotating machine constituted at least by the distributor 5, turbine 6, compressor 9 and outlet rectifier (vanes 11).

This purpose can be achieved by simply using automatic regulation of the angular setting of the blades of at least one ring of blades of the said machine, in dependence

on the rotational speed of the alternator, for example, and advantageously a regulation of the setting of the blades of the distributor 5 of the turbine 6, by means of a jack 22 influenced by the rotational speed of the alternator.

Such regulation necessarily acts at the same time on the proportion of the cooling fluid utilised by the apparatus to be cooled, in a manner which is not necessarily adapted to the operational requirements.

This is why there must also be provided at least one correcting device for the regulation of the proportion of cooling fluid.

The said correcting device can be constituted by an assembly 15, 16, 17, 18 and 19, as illustrated in Figure 1 and by a jack 23 (Figure 2) adapted to regulate appropriately the setting of the vanes 11 under the influence of the thermostat 16.

In fact, if the cooling to be produced at apparatus 21 is to be kept constant it is sufficient to by-pass a proportion of the liquid flow issuing from the pump so as to keep the temperature of the fluid at the inlet of the apparatus 21 constant.

The two solutions which have just been described are satisfactory in many cases. However, they both have certain disadvantages.

According to the embodiments illustrated in Figures 3 and 4, there is provided for driving the alternator 12 a supplementary turbine 24 which is independent of the turbine driving the compressor and is arranged in series with the latter turbine, and automatic regulating means are used to make the rotational speed of this supplementary turbine constant.

For this purpose, it is possible for example, as shown in Figure 3, to provide, forwardly of the distributor 5, an auxiliary turbine 24 comprising at least one stage and of axial or centripetal type, which turbine 24 is preceded by a distributor 25 and drives the alternator 12 (which is here mounted within the axial cone 3 forwardly of the turbine 24) by a shaft 26 resting on two bearings 27, 28 supported within a tubular element 29 fast with the structure of the nacelle. The shaft 8 which connects the turbine 6 to the compressor 9 itself rests on two bearings 30, 31 which are supported within a tubular element 32 fast with the structure of the nacelle.

In such an assembly it is necessary to choose a main regulating parameter which in this case will be the electrical power (dependent on the rotational speed of the alternator), in which case the secondary parameter i.e. the cooling capacity is regulated to a constant value only to an extent which does not impair the first-mentioned speed regulation, thus the regulation of the secondary parameter can only be approximate.

It is also to be remarked that, according to the embodiments shown in Figures 3 and 4, the introduction of an additional degree of liberty, namely the independence of the shafts 8 and 26 permits of much more effective action on the cooling regulation since what are then concerned are two machines having separate functions and each having its regulating member. Under these conditions, the regulation of the secondary parameter, that is to say the cooling capacity, influences only slightly the regulation of the main parameter.

The regulation of the cooling capacity can be effected as shown in Figure 3, according to which the temperature at the inlet of the apparatus to be cooled is regulated by acting on the vanes 11 of the rectifier, within limits such that no interference with the regulation of the electrical power results. The additional regulation is effected by by-passing cooling liquid as illustrated in Figure 1 (elements 15, 16, 17, 18, 19 and 20).

As for the regulation of the speed of the turbine 24, this can be effected by varying the angular setting of the blades of at least one of the rings of blades carried respectively by the distributors 5 and 25, by the turbines 6 and 24 and by the outlet rectifier (vanes 11).

Thus, it is possible, for example, to act on the blades of the distributor 5, which blades are then mounted in swingable fashion and are so controlled that the speed of the turbine 24 remains constant under predetermined conditions of use.

It would also be possible to make only the setting of the blades of the distributor 25 adjustable in order to obtain the desired regulating effect.

As far as the vanes 11 of the outlet rectifier are concerned, they can advantageously be constituted in every case by an upstream fixed portion 33 (Figure 5) and a downstream portion 34 which is pivotable in the manner of a trailing edge flap about a pin 35.

As shown in Figure 4, the alternator 12 may be shifted right to the rear of the assembly. According to this form of embodiment, the turbines 6 and 24 are situated one with respect to the other in the manner shown in Figure 3, but the turbine 24 (situated forwardly) is connected to the alternator 12 (situated rearwardly) by an internal shaft 36 disposed within a hollow shaft 37 (replacing the shaft 8 in Figure 3). Here, the shaft 36 rests in bearings, 38, 39 supported by the structure of the nacelle, whilst the shaft 37 rests on bearings 40, 41 supported by the shaft 36 itself.

The invention is not limited to the particular constructions described above. For example, as shown in Figure 6, the cooling installation does not have an electrical generator added thereto as in the other Figures. In this case it would be possible to regulate the cooling power with a simplified arrange-

ment such as that shown in Figure 6, according to which the thermostat 16, connected to the duct 15 leading from the exchanger 7 to the apparatus to be cooled, only influences the jack controlling the angles of the vanes 11.

Again, in order to vary the cross-sections of passage offered to the air through the installations, use would be made of any means other than those employing variation of blade settings. Thus it would be possible as shown in Figure 4, to vary the inlet cross-section for the air into the installation by moving the axial cone 3.

WHAT WE CLAIM IS:—

1. Cooling installation for high-speed aircraft, of the type wherein air collected by an air intake which is forwardly directed is expanded in a driving turbine which drives a compressor, the cooled air issuing from the turbine passing through a heat exchanger where the heat of a cooling fluid returning from apparatus to be cooled is dissipated, and then the said air passes through the said compressor from which it is ejected preferably outwardly and rearwardly, characterised in that the said installation is completed by means for generating electrical energy, preferably in the form of a constant-frequency alternating current, the motive power for said energy generating means being provided by the air flowing through the installation.

2. Installation according to Claim 1 characterised in that the turbine which already drives the compressor also drives an electrical generator.

3. Installation according to Claim 2, characterised in that the turbine-compressor system is of a fixed-geometry type, the electrical generator being an alternator which is driven through a speed reduction gear and delivers through a frequency regulating device.

4. Installation according to Claim 2, characterised in that the regulation of the temperature of the fluid arriving at the apparatus to be cooled is carried out by a thermostat influenced by the temperature of the fluid passing through a duct leading from the heat exchanger to the apparatus to be cooled, the said thermostat acting on an electro-magnetic valve in order to by-pass around said heat exchanger and direct directly towards the said duct, when necessary, at least part of the delivery of a pump effecting the circulation of the cooling fluid.

5. Installation according to Claim 2, characterised in that it comprises means for keeping the rotational speed of the turbine and the compressor substantially constant.

6. Installation according to Claim 1, characterised in that it comprises an additional turbine separate from the turbine driving the compressor, this additional turbine driving an alternator and the two turbines being arranged in series in the airflow and automatic regulating means, preferably in association with means which regulate the temperature of the fluid arriving at the apparatus to be cooled, being provided in order to keep the rotational speed of this additional turbine constant.

7. Installation according to Claim 6, characterised in that the regulation of the temperature of the fluid arriving at the apparatus to be cooled is carried out by a thermostat influenced by the temperature of the fluid passing through a duct leading from the heat exchanger to the apparatus to be cooled, this thermostat acting on an electro-magnetic valve in order to by-pass around said heat exchanger and direct directly towards the said duct, when necessary, at least a portion of delivery of the pump effecting the circulation of the cooling fluid, the regulation of the speed of the said turbine.

8. Installation according to Claim 7, having means for acting on the setting of the blades of an air distributor at the inlet of the turbine which drives the compressor.

9. Installation according to Claim 7, having means for acting on the setting of the blades of an air distributor at the inlet of the turbine driving the alternator.

10. Installation according to Claim 6, characterised in that the alternator is situated at the rear of the installation and is driven by the additional turbine through a shaft extending co-axially within the shaft connecting the turbine driving the compressor with the compressor.

11. Installation according to Claim 1, characterised in that at the outlet through which the air is ejected rearwardly by the compressor there are provided means for automatically varying the cross-section of the outlet presented to the air discharged by the compressor.

12. Installation according to Claim 11, characterised in that adjustable rectifying vanes are provided in the air outlet duct.

13. Installation according to Claim 12, characterised in that the rectifying vanes are constituted by a fixed upstream portion and a pivotable downstream portion.

14. In stallation according to Claim 11, having means for regulating the cooling capacity, these means being constituted by a thermostat influenced by the temperature of the liquid passing from the heat exchanger to the apparatus to be cooled, and the said thermostat actuates the means for automatically varying the outlet cross-section presented to the air delivered by the compressor.

15. Cooling installation for high-speed aircraft, constructed and arranged substantially as described herein with reference to Figure 1, 2 or 3, or Figures 4 and 5, or Figure 6 of the accompanying drawings.

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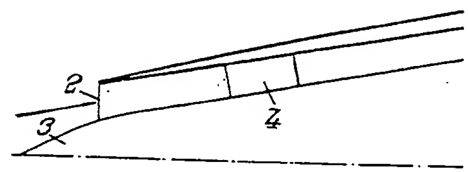
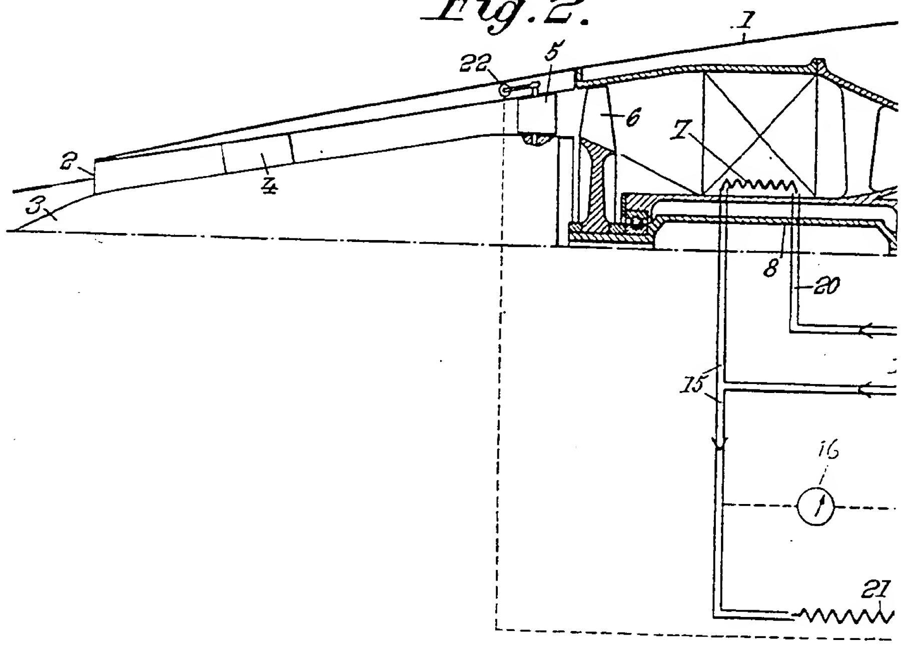


Fig.2.



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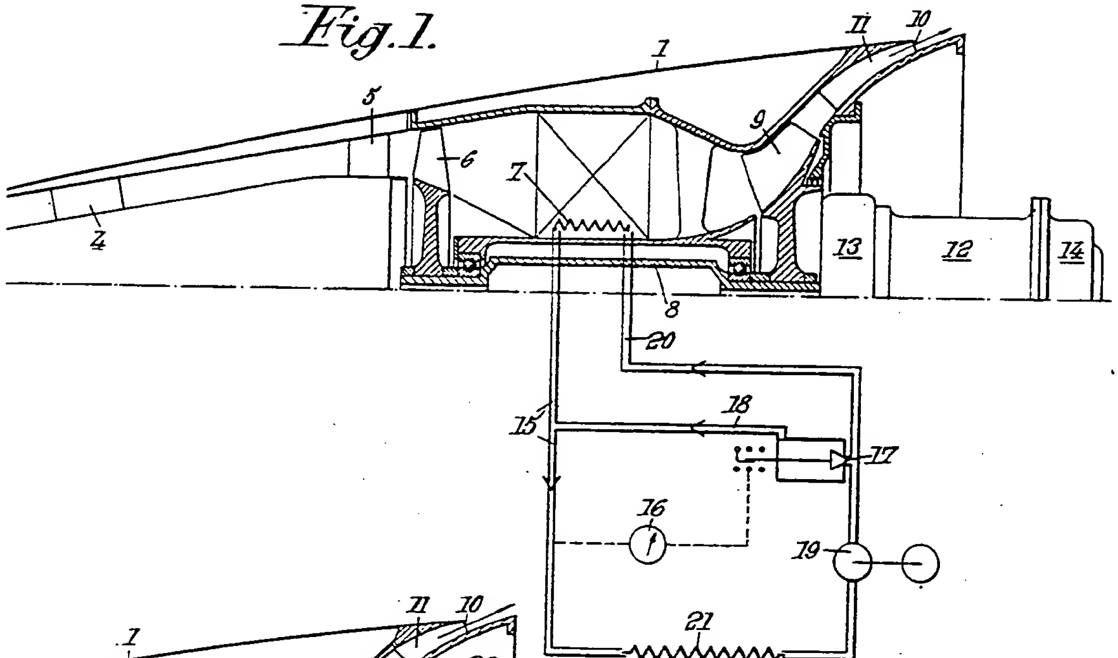
Sheet 1

Fig.1.



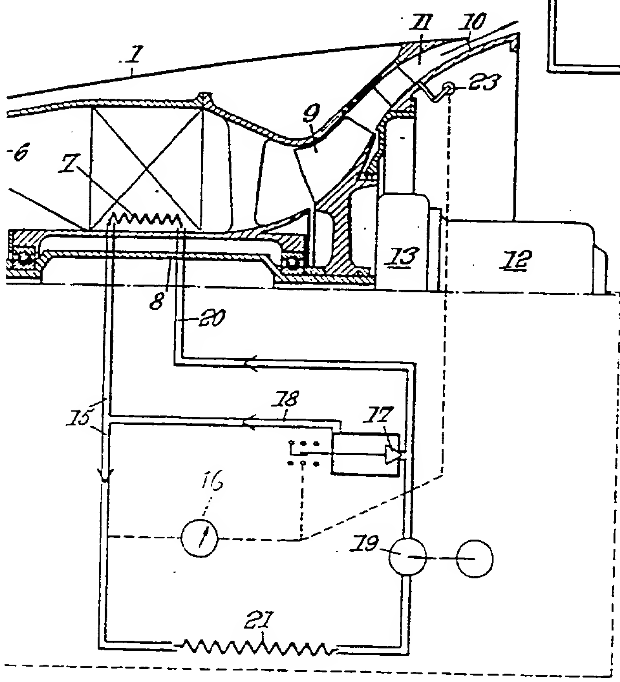


Fig.1.

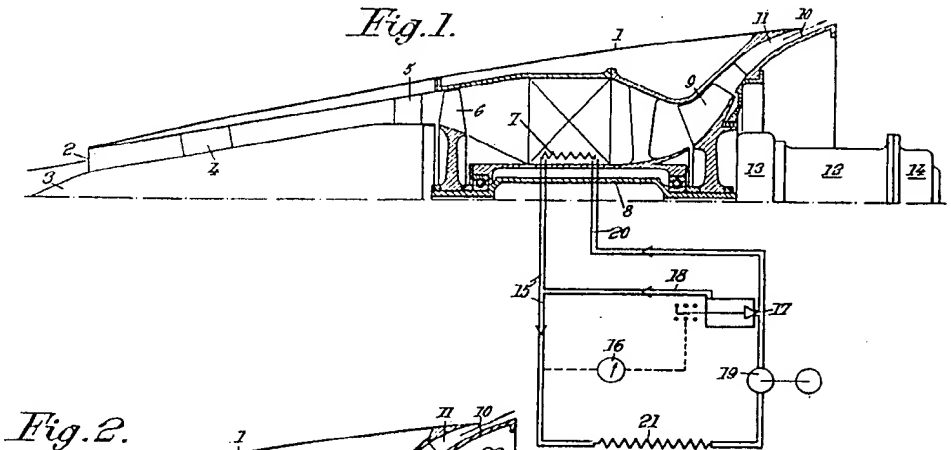

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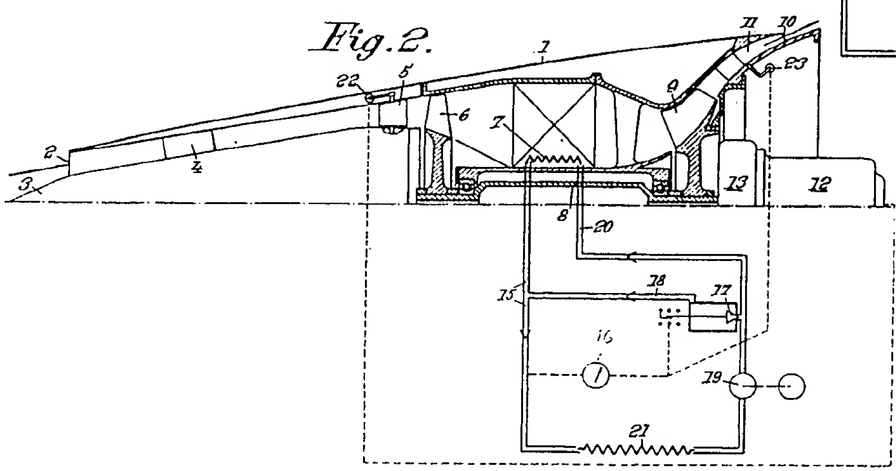
Fig.2.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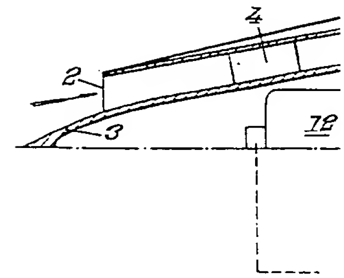


Fig.4.

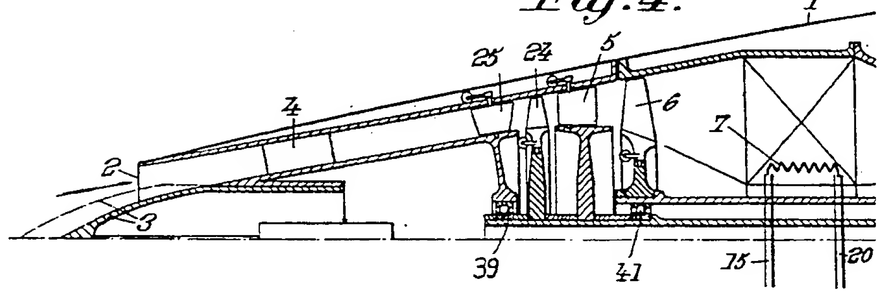
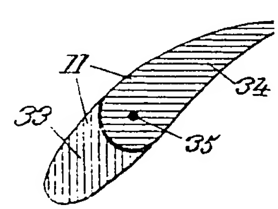


Fig.5.



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Sheet 2

Fig. 3.

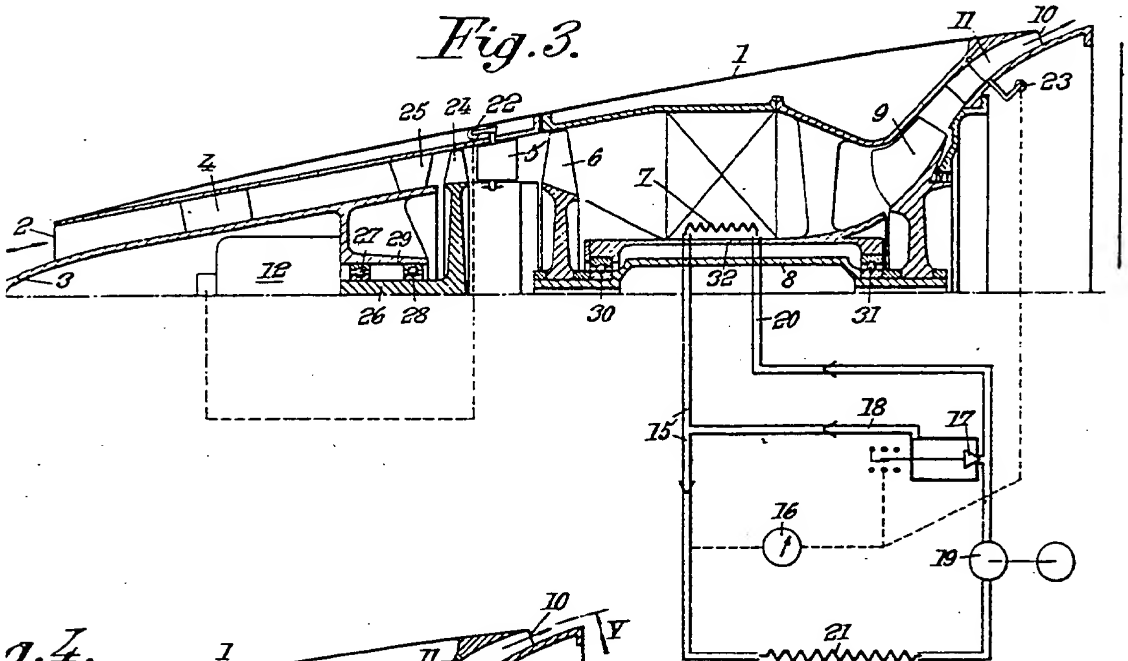


Fig. 4.

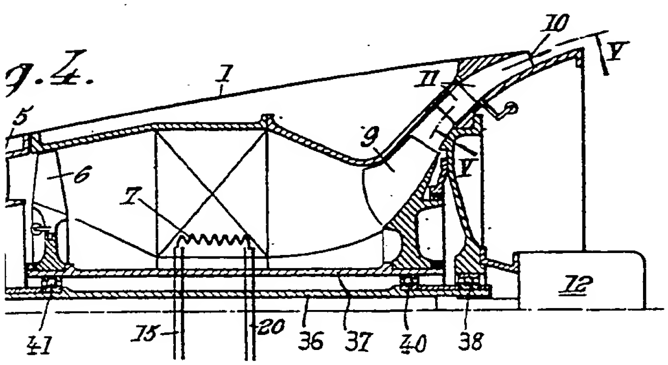
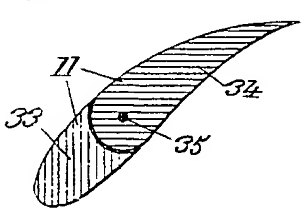


Fig. 5.



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Sheet 2

Fig.3.

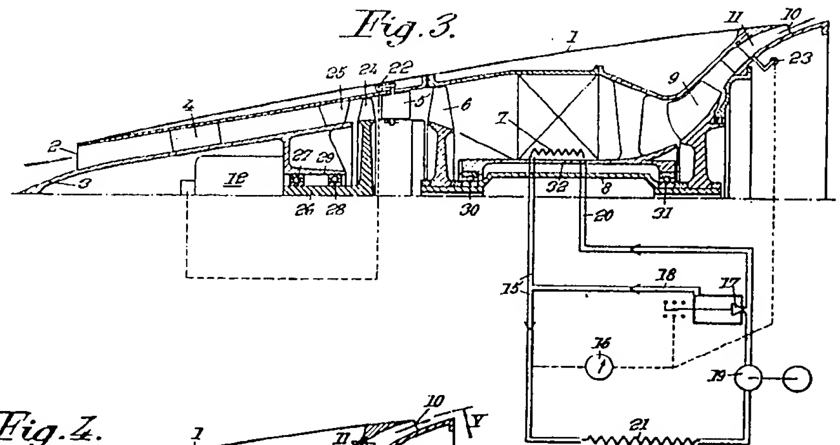


Fig.4.

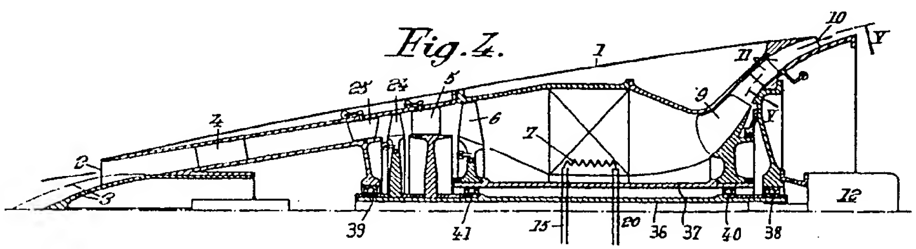


Fig.5.

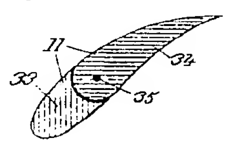
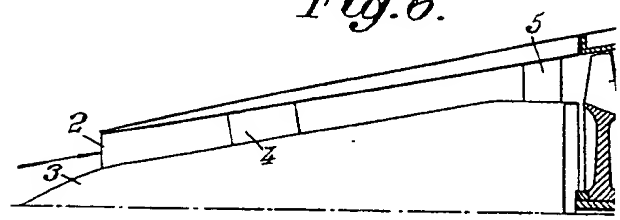


Fig.6.



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Sheet 3

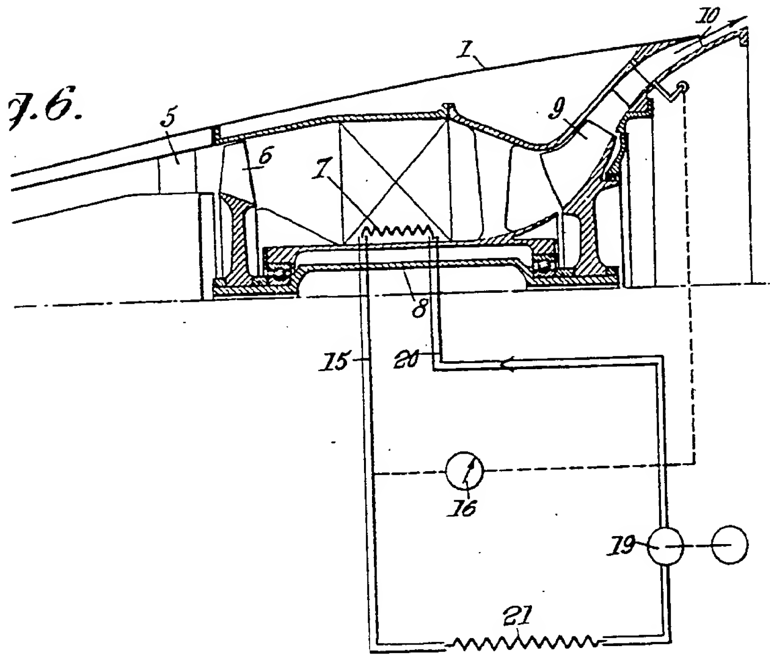

Fig. 6.